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Critical Literature Review

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Airborne asbestos fibres and mesothelioma in the last 20 years in Egypt: a review

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ABSTRACT

Asbestos has been used in Egypt ever since 2000 – 3000 BC for embalming the bodies of Egyptian pharaohs. Little data is available on airborne asbestos fibre counts in the occupational and environmental settings. Counts ranged between 0.0 – 2.7 f/cc and 0.007 – 3.0 f/cc inside and outside various industrial workplace sites, respectively at Sigwart (El–Maasara and Shoubra El–Kheima) companies in Cairo. Asbestos counts ranged between 0.0244 – 0.1389 f/cc in the surrounding areas of the ORA–Egypt company in the 10th of Ramadan City, which has been shut down since 2004. Malignant pleural mesothelioma (MPM) is becoming an increasing problem in Egypt. MPM is related to the inhalation of asbestos fibres in low counts and is incurable when diagnosed. According to official registry data, most MPM cases were living close to asbestos production companies. Mesothelioma incidence was analyzed and studied in the available data during the period 1984–2005. Mesothelioma incidences increased from 159 cases during 1984 – 1999 to 733 cases during 2000 – 2005. The age of the patients ranged between 17 to 90 years with a mean age of 54 years. The survival age varied between 6 to 15 months with median survival was approximately 1 year from diagnosis. Females represented ~39 % of the cases and males represented ~60% with male to female ratio of ~1.7.

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1. Introduction

Asbestos is a naturally occurring family of minerals formed by the combination of magnesium and silicon that have a strong fibrous and crystalline structure. Serpentine and amphibole are the main groups of asbestos. Serpentine includes only chrysotile, while amphibole contains amosite, actinolite, anthophyllite, crocidolite and tremolite (ATSDR, 2001). Chrysotile is the common asbestos type used and accounts for 95% of the world's production (Smith and Wright, 1996).

Asbestos has been recognized in Egypt for a long time as it was used by Egyptians for mummification (Abratt et al., 2004). Industrialization utilizing asbestos started in Egypt in 1948 by Sigwart El–Maasara Company in south Cairo, after which 14 asbestos factories were presented by the year 2004 (Allen, 2006).

Asbestos has been recognized as a health hazard in industrial workplaces (Selikoff and Lee, 1978) and inhalation of asbestos fibres can cause asbestosis, lung cancer, bronchogenic carcinoma and mesothelioma (Hughes, 2005). Mesothelioma is a cancer arising from the mesothelial cells that line the pleural, pericardial and peritoneal surfaces (Carbone et al., 2002). Mesothelioma occurs in selected individuals among population groups, with known exposure to asbestos either in the workplace or in the community. Di Maria and Comba (2004) have reported that most persons exposed to asbestos inhalation do not develop mesothelioma, whereas others are affected by mesothelioma in the absence of association with previous occupational or environmental exposure to asbestos.

Malignant mesothelioma is a rare neoplasm that could be favored by a hereditary predisposing factor such as Ehlers–Danlos syndrome and Marfan's syndrome (Bisconti et al., 2000). Genetic predisposition to mineral fibre carcinogenesis has led to an epidemic of mesothelioma in Turkey and some US families (Roushdy–Hammady et al., 2001; Dogan et al., 2006).

In the United States there are 2 500 cases and deaths per year of malignant mesothelioma which is often related to asbestos exposure (Carbone et al., 2007). Mesothelioma incidence rates are predicted to increase dramatically in developing countries due to poor regulation of asbestos mining and proliferation of industrial and household utilization of asbestos (Giaccone, 2002). Mesothelioma continues to be a global problem due to ongoing exposure to fibres and as a legacy from past exposure to asbestos, even in countries where asbestos is currently banned or has been regulated–out of use for decades (McElvenny et al., 2005). Mesothelioma is an increasing problem in Egypt (Eldin and Mourad, 2003) and the incidence of mesothelioma is rising (Gaafar and Eldin, 2005). Epidemiological and environmental studies regarding exposure–response relationships between asbestos fibre counts and mesothelioma rates are lacking in Egypt. This review aims to present the current available data of airborne asbestos fibre counts and mesothelioma cases in the last 20 years in Egypt.

2. Methods

2.1. Air sampling and analysis of asbestos fibres

Airborne asbestos samples were taken inside and outside of different industrial workplace sites at Sigwart El Maasara and

Sigwart Shoubra El Kheima that are located in south and north Cairo, respectively. Asbestos samples were collected from the air surrounding the residential areas in a circular area ~0.5 – 7 km in radius. Sigwart are considered the biggest asbestos–cement manufacturing companies in Egypt. Airborne asbestos samples were also collected around ORA–Egypt factory which is located in the 10^{th} of Ramadan City ~60 km north–east of Cairo. The ORA Egypt factory has been shut down since 2004.

Air samples were collected on membrane filters (0.45 µm pore size, 25 mm diameter) mounted on an open face filter holder according to NIOSH method No 7400 (NIOSH, 1994), for a period varying between 60 – 120 min at a flow rate of 5 L/min. The collected samples were stored in upward position in sealed boxes and brought to the Air Pollution Laboratory at the National Research Centre for analysis. The membrane filters were made transparent by mounting in immersion oil.

The mounted samples were analyzed for the presence of asbestos fibres at a magnification of 400X using phase contrast microscopy (Olympus, Tokyo, Japan). Asbestos fibres with dimensions >5 µm in length, <3 µm in diameter and aspect ratio 3:1 were considered for counting. A minimum of 25 – 50 fields were screened for counting of fibres using Walton Beckett reticule in the eye piece. Zakaria and his coworkers (1989) counted asbestos samples by using a Carl–Zeiss Konimeter 10. This method only counts particles using relatively low powered microscopy and overlooks many of the respirable fibres and is a very indirect measure of the fibre level.

Air sampling was mainly done by a research team from the Air Pollution Department, National Research Centre, Egypt. A minimum of 3 samples were collected at each sampling site. The sampling period was between 10 am and 3 pm and no clear pattern for sampling days had been chosen. The count of asbestos fibres was expressed as the number of fibres per cubic centimeter (f/cc).

2.2. Epidemiological data

Information on mesothelioma cases were obtained from the National Cancer Institute (NCI) and the Abbassia Chest Hospital (ACH) in Cairo during the period between 1989 and 2007. Other information on mesothelioma was extracted from the available reports and research articles. The diagnosis of malignant mesothelioma is dependent on an assessment of clinical and radiological findings in conjunction with pleural fluid cytopathology and pleural biopsy (Suzuki, 1992).

The main limitations of this review were the absence of specific procedures for mesothelioma identification and counting as well as no data available on the presence of other mesothelioma types (as peritoneal mesotheliomas).

2.3. Statistical methods

The differences between airborne asbestos fibre counts in the different workplace sites inside and outside of asbestos plants were analyzed by t–test and Mann Whitney U test. Correlation coefficient was used to find out the correlation between the number of MPM cases and asbestos fibre counts.

3. Results

3.1. Epidemiological features of mesothelioma

Epidemiological features of mesothelioma in Egypt. Zakaria and coworkers (1989) diagnosed 13 (9 females and 4 males) mesothelioma patients between 1984 – 1987 which came from an area of ~4.7 km radius in the neighborhood of Sigwart El–Maasara Company, south Cairo (Table 1). None of the cases had a history of occupational asbestos exposure, but all had been living near the Sigwart El–Maasara Company. In the period 1989 – 1999, 148 cases of mesothelioma were diagnosed and treated at NCI, Cairo University. Females represented 36.5%, with male to female ratio of 1.7. Residential asbestos exposure was 81.1% whereas occupational exposure was 13.5% (Eldin et al., 2005) (Table 2).

Table 1. *Age and sex of patients with pleural mesothelioma during the period 1984-1987 (Zakaria et al., 1989)*

Age /year	Male	Female	Total	
			No	%
<20	-	2	2	15.38
20-30	1	-	1	7.69
31-40	1	1	2	15.38
41-50	1	3	4	30.77
>50	1	3	4	30.77
Mean/age	43.25	43.55	43.46	

In the first 4 years of the 3^{rd} millennium (2000 – 2003), 635 cases of mesothelioma were diagnosed at NCI and ACH, Cairo. Both hospitals drain and serve most of the high risk populations living in the neighborhoods of the Sigwart Companies (Eldin et al., 2005). The median age was 53 years (19 – 90). Females represented 39.2% and young adults ≤40 years represented 19.1%. Residential exposure was evidenced in 64.7% of cases (Shoubra El Kheima, 35.6%, El Maasara, 23.6%, El Zeytoon 5.2% and other exposed areas 0.5%). Twenty five percent of the mesothelioma cases came from other Cairo areas while 9.8% came from other governorates (Eldin et al., 2005) (Table 2). The NCI hospital–based registry showed an increase in the relative frequency of MPM from 0.47% in the year 2002 to 1.3% in the year 2003.

Table 2. *Epidemic features of mesothelioma in Egypt during the periods 1989-2003 (Eldin et al., 2005)*

Years	Epidemic features of mesothelioma
1989-1999	- 148 cases of MPM were diagnosed and treated at NCI, Cairo Univ., Egypt. - Median age was 48 (17-85) years - Young adults ≤ 40 years represented 29.7%. - Male/female 1.7 - Residential asbestos exposure was 81.1% - Occupational 13.5%. - Median duration of exposure was 32 years - Median overall survival was 7 months.
2000-2003	- 635 cases of MPM were diagnosed at NCI and Abbasia Hospital Cairo, Egypt. - Median age was 53 (19-90) years. - Young adults ≤ 40 years represented 19.1%. - Females represented 39.2% - Residential exposure was evidenced in 64.7% of cases (Shoubra El-kheima 35.6%, El Maasara 23.6%, and El Zytoon 5.2%). - 25% came from other Cairo areas and 9.8% from other governorates.

Hussin (2007) studied the epidemic mesothelioma among 487, 2 913, and 979 people occupationally, environmentally and control, exposed to asbestos in Shoubra El–Kheima, north Cairo, respectively. He recorded a total of 88 MPM cases, among them 4 cases were occupational, 83 environmental and 1 non–exposed person (Table 3). MPM was more prevalent in the environmentally exposed group (83/2 913, 2.8%) than in the occupationally exposed group (4/487, 0.8%) and control group (1/979, 0.1%) (Table 3). The control area was an agricultural village located at Banha city ~40 km north of the asbestos plant. People who agreed to be included in the study were 979 people chosen by cluster sampling, a response rate of 94%. None of those individuals had a history of occupational or environmental exposure to asbestos fibers.

Table 3. The prevalence of MPM cases among environmentally, occupationally and non-exposed groups in different areas surrounding Sigwart Shoubra El Kheima over the period 2003-2005 (Hussin, 2007)

Area	No. of population exposed	No. examined	Mesothelioma cases	
			No	%
Environmentally exposed	322 109	2 913	83	14.8
El Wehda El Arabia (100 m)	56 228	873	39	4.5 [a]
Manshiyat El Gadida (800 m)	20 000	644	17	2.6
Manshiyat El Horriya (1 km)	67 832	335	8	2.4
Ezbet Osman (1 km)	25 000	412	9	2.2
Manshiyat Abdel Moniem Raid (2 km)	128 215	318	6	1.9
Ezbet Rostom (2.5 km)	24 834	331	4	1.1
Occupationally exposed		487	4	0.8
Non-exposed (control)		979	1	0.1

[a] *P≤0.001*

There was a significantly (*P*<0.001) higher prevalence of MPM cases in El–Wehda Arabia area (4.5%) which lies 100 m away from the asbestos company compared to Ezbet Osman area which had the lowest prevalence (1.1%). Moreover, there was a significant positive correlation (*P*<0.001) between airborne asbestos fibre counts and number of mesothelioma cases among environmentally exposed patients (Hussin, 2007). The mean age of patients with MPM was 51.3 years; 54.1 ± 8.5 years (range 39 – 70 years) for males and 49.5 ± 7.4 years (range 35 – 60 years) for females (Hussin, 2007). Females and males represented 61.4% and 38.6% of MPM cases respectively, diagnosed between Shoubra El–kheima's residents (Hussin, 2007).

Evidence from other countries. Sheard et al. (1991) found that the mean age of MPM cases was 54.1 years. The median latency from time of asbestos exposure to disease development is ~32 years and ranged from 20 to ~50 years (Pass et al., 2005). The shortest lag time between first exposure and death with mesothelioma was 20 years for residents compared with 13 years in the former workers (Berry et al., 2004). For exposures starting at age 30, the excess mortality estimate is applied to the total expected mortality from age 40 to age 79 and about 70% of survivors to age 30 will die between the ages of 40 and 80 years in Cappadocia, Turkey (Umran, 2003).

Incidence of mesothelioma was found to be higher in populations living near naturally occurring asbestos than those non–exposed. Mesothelioma is rare between cohorts that are not exposed to asbestos, but it is frequent in workers who are exposed to it (Sluis–Kremer, 1991). In central Cappadocia, Turkey mesothelioma caused 50% of all deaths in three villages, Tuzköy, Karain, and Sarihidir. Initially, this was attributed to erionite, a zeolite mineral with similar properties to asbestos, however, detailed epidemiological investigation showed that erionite causes mesothelioma mostly in families with a genetic predisposition (Umran, 2003). There was statistically significant interaction between asbestos exposure, mesothelioma and sex (Reid et al., 2007). The rate of mesothelioma is higher in males and those ≥15 years of age at first exposure, but women had a steeper dose–response curve than men; however their risk was lower than that for men (Reid et al., 2007). Reid et al. (2008) concluded that women who were former residents of Wittenoom, Western Australia, exposed to asbestos in their environment or in their houses, had excess cancer mortality including mesothelioma compared with the Western Australian female population. Madkour et al. (2009) attributed the predominance of MPM cases between females in the vicinity of Sigwart Company (Shoubra El–Kheima) to their long duration of residency.

3.2. Environmental and occupational assessment of airborne asbestos fibers

Neighborhood areas in Egypt. Zakaria and coworkers (1989) evaluated asbestos fibre counts in the air environment near to Sigwart–El Maasara Company in an area of ~5 km radius. They found fibre counts in the range of 0.00 – 5.4 f/cc with the highest mean count at the Autostrade road site (4.6 f/cc), located immediately close to disposal site of the asbestos plant (Table 4). Eldin and coworkers (2005) investigated asbestos fibre counts in a an area of ~0.5 – 7 km radius surrounding the Sigwart El–Maasara Company. They found asbestos fiber counts in the range of 0.002 – 3.02 f/cc with the highest count (3.02 f/cc) at the Autostrade road sampling site (Table 5). These results agree with those reported previously by Zakaria and coworkers (1989). This observations are attributed to the improperly disposed asbestos wastes near the road. However, Tag Eldin et al. (2002) found asbestos fibre counts in the range of 7 – 13 f/cc in an area of 0.5 – 1.5 km radius from Sigwart El–Maasara Company.

Table 4. *Airborne asbestos fibre counts at various locations surrounding Sigwart El Maasara (Zakaria et al., 1989)*

Location	f/cc	
	Range	mean
North	0.21-2.5	0.21
North west	00	00
South east (Autostrade road)	0.42-8.3	4.6
South west	0.17-0.25	00
East	3.8-5.4	3.45

Eldin (2008) evaluated airborne asbestos fibre counts in the surrounding area of Sigwart El–Maasara after asbestos was banned. She found asbestos fibre counts in the range of 0.0044 – 0.358 f/cc with the highest count (0.358 f/cc) detected at the main gate sampling site. Moreover, she found airborne asbestos in lower count (0.1407 f/cc), at the Autostrade road sampling site, than the count found (3.02 f/cc) in the year 2005 (Table 5). This was attributed to asbestos wastes which have been covered by construction materials and no more waste was being disposed on the roadside. Surprisingly, asbestos fibres were recorded at El Maadi area (~7 km north of El Maasara Company) at mean values of 0.05 f/cc and 0.0044/f.cc in the years 2004 and 2008, respectively. This was attributed to the fact that asbestos fibres can travel to considerable distances owing to their aerodynamic properties without mechanical breakdown. Moreover, chrysotile fibres may split into fibrils that are easily released and transported in the atmosphere by wind and human activities.

Table 5. *Airborne asbestos fibre counts in the residential areas surrounding the Sigwart El Maasara*

Location	f/cc	
	Eldin et al. (2005)	Eldin (2008)
	mean	mean
El-Maadi (~5 km north)	0.002	0.0044
Hadayk Helwan (100 m south)	0.02	0.069
El Maasara (100 m north)	0.062	0.0887
El- Maasara (the main gate)	0.057	0.358
Autostrade	3.02	0.1407
East, 25 m of the factory wall		0.058

Hussin (2007) evaluated airborne asbestos fibres at the surrounding residential areas in ~0.5 – 2.5 km radius, at Sigwart Shoubra El–Kheima, north Cairo. The fibre counts ranged between 0.021 to 2.6 f/cc, and the counts decreased downwind as the distance increased from the company. The residents at Al Wehda Al Arabia (100 m away) were exposed to higher fiber count (2.6 f/cc) compared with the other residential areas surrounding the Company (Table 6).

Table 6. *The mean counts of airborne asbestos fibres in the surrounding areas close to the Sigwart Shoubra El-Kheima Company (Hussin 2007)*

Location	f/cc	
	Mean	SD
El Wehda El Arabia	2.16 [a]	0.16
Manshiyat El Gadida	0.04	0.01
Manshiyat El Horriya	0.021	0.0005
Ezbet Osman	0.021	0.002
Manshiyat Abdel Moniem Raid	0.025	0.004
Ezbet Rostom	0.021	0.003

[a] *P<0.01, SD=standard deviation*

Asbestos fibre counts at the borders of the ORA–Egypt factory located in the 10th of Ramadan City, north–east Cairo are shown in Table 7. The ORA–Egypt factory has been shut down since the year 2004. The mean counts of asbestos fibres ranged from 0.024 to 0.1389 f/cc with the greatest count found in the south side (along the prevailing wind direction). A lot of manufactured cement–asbestos pipes have been exposed to the air where weather and wind action help release fibres and fibrils into the atmosphere. In addition, asbestos wastes were not properly disposed of in landfills with special precautions, but were thrown improperly near the factory.

Table 7. *The mean counts of airborne asbestos fibres at the borders of the ORA-Egypt Company in 10th of Ramadan city*

Location	f/cc
East	0.0244
North	0.069
West	0.1318
South	0.1389

Occupational assessment of airborne asbestos fibres in Egypt. Few studies have been carried out to determine airborne asbestos fibre counts in the occupational environments. The highest asbestos fibre count was found at the disposal site (2.79 f/cc), outside the working environment of Sigwart El Maasara Company (Table 8). Significant differences (*P*<0.001) were found between asbestos fibre counts at the disposal sites and other sites (Table 8). The disposal sites at both companies were uncovered and asbestos was exposed to mechanical and environmental factors. Asbestos fibre counts decreased from 0.16 f/cc just outside the production hall (El Maasara Company) to 0.05 f/cc at the nearby residential homes. It was reported that (Anonymous, 2002; Hussin, 2007) airborne asbestos mean fibre counts were 0.983 f/cc/0.76 f/cc; 0.313 f/cc/ 0.239 f/cc and 0.0732 f/cc/ 0.183 f/cc at milling, cutting and storage halls, respectively (Table 8). The differences between fibre counts may be attributed to pollution mitigation measures and stronger legislative measures taken to reduce the asbestos fibre emissions.

Data from other countries. Many studies have revealed that asbestos fibre counts were $1x10^{-4}$ f/cc in rural areas (NRC, 1984), $1x10^{-4}$ – $1x10^{-3}$ f/cc in urban areas (Commins, 1985) in USA and $2.2x10^{-2}$, $8x10^{-3}$ and $6x10^{-3}$ f/cc at 300 m; 700 m and 1 000 m downwind distances of asbestos plants, respectively, in Germany (Marfels et al., 1984). In India, Ansari et al. (2007) analyzed 15 airborne asbestos samples that were collected from asbestos–cement manufacturing plants. They found asbestos fibre counts at mean values of 0.079 f/cc, 0.057 f/cc and 0.078 f/cc at ingredient feeding, sheet producing and fibre godown sites, respectively. Also, Ansari et al. (2010) collected and analyzed a total of 24 air asbestos samples at three different plants of an asbestos cement roofing sheet manufacturing industry located in North India, by phase contrast and polarized light microscopy. They found chrysotile asbestos fibers in average concentrations ranging between 0.036 – 0.148 f/cc (a mean value of 0.075 ± 0.034 f/cc).

Table 8. *The counts of airborne asbestos fibres in different occupational sites at Sigwart Companies*

Workplace site	Sigwart El-Maasra [a]		Sigwart Shoubra El-Khiema [b,c]	
	Range f/cc	Mean f/cc	Range f/cc	Mean f/cc
Indoor working environment				
Preparation unit	0.38-0.4	0.68	n.m.	n.m.
Production unit	0.086 - 0.78	0.21	0.256-2.7	0.76/0.98 [c]
Machine	0.07 - 0.4	0.135	0.07-0.405	0.25
Wetting and drying area	0.04 - 0.16	0.1	n.m.	n.m.
Cutting	n.m.	n.m.	0.074-0.387	0.239/1.00 [c]
Store	0.05 - 0.7	0.3	0.05-0.6	0.183/0.073 [c]
Office	0.3 - 0.65	0.445	n.m.	0.126
Outside working environment				
Entrance gate	0.04 - 0.232	0.102	0.04-0.18	0.007
Outside of production hall	0.1 - 0.23	0.16	n.m.	0.92
Disposal area	1.8 - 3	2.79 [d]	0.231-3	2.33 [d]
Nearby residential area	0.007 - 0.08	0.05	0.05-1.37	n.m.

[a] *(Nasralla 1996),* [b] *(Hussin 2007),* [c] *(Anonymous 2002),* [d] *P<0.001, n.m.: not measured*

***Table 9.** Estimates of the risk of mesothelioma resulting from lifetime exposure to airborne asbestos fibres*

Risk of mesothelioma from 0.001 f/cc	Value in original publication (risk for fibre concentration indicated)	Reference
$1x10^{-5}$	$1x10^{-4}$ for 0.001 f/cc	Aurand and Kierski (1981)
$2x10^{-5}$	$1x10^{-4}$ for 0.00013-0.0008 f/m^3	Schneiderman et al. (1981)
$3.9x10^{-5}$	$1.56x10^{-4}$ for 0.0004 f/m^3	Breslow et al. (1986)
~$2.4x10^{-5}$	$2.75x10^{-3}$ (females) $1.92x10^{-3}$ (males) for 0.01 f/cc	EPA (1985)

Several studies have been performed to calculate the risk of mesothelioma resulting from nonoccupational exposure to asbestos fibres. Lifetime exposure to 0.0001 f/cc has been estimated by various authors to carry differing degrees of mesothelioma (Table 9). In USA, Enterline (1983) estimated that exposure to asbestos fibre counts in the range of 0.0002 – 0.0005 f/cc resulted in a lifetime risk of mesothelioma of 4 – 10x10^{-5}. He reported that mesothelioma incidence ranged from 1.4x10^{-6} to 2.5x10^{-6} per year. Australia's high incidence of mesothelioma is related to high past asbestos use of all fibre types, in a wide variety of occupational and environmental settings. The number of cases in total is expected to be about 18 000 by 2020 (Leigh et al., 2002). Price and Ware (2004) used an age cohort model to analyze mesothelioma incidence in Surveillance, Epidemiology and End Results (SEER) database over the period 1973 – 2000 in USA. Their results suggested that age adjusted rates among males reached a peak around early to mid 1990s and have remained relatively constant or declined somewhat since then. They also reported that the age adjusted rates for females are much lower and have remained more or less constant over the period of 1973 – 2000. Moolgavkar et al. (2009) estimated approximately 62 000 and 32 000 pleural mesotheliomas among men and women, respectively, over the period 2005 – 2050 in USA. The larger number of pleural mesotheliomas among men reflects the continuing but declining, impact of asbestos use on pleural mesothelioma.

4. Discussion

Exposure to asbestos fibres could cause health risks as all asbestos types are toxic to macrophages in vitro and can cause fibrosis and carcinoma (Ohar et al., 2004). According to some experts only amphibole asbestos, particularly crocidolite and amosite, causes mesothelioma. Chrysotile does not cause disease and mesothelioma associated with chrysotile exposure is probably caused by the contamination with tremolite (McDonald and McDonald, 2005). Some authors claim that chrysotile is as dangerous as amphibole asbestos and consider chrysotile the main cause of mesothelioma development because it accounts for about 90% of all exposures (Smith and Wright, 1996). The present review confirms that chrysotile is the main causes of MPM in Egypt and the risk of mesothelioma from the currently exposed concentrations in the range of 0.0001 f/cc to 0.001 f/cc cannot be excluded.

This review shows that asbestos fibre counts did not exceed the Egyptian allowable count of 2 f/cc for chrysotile (EEAA, 1994), except at the disposal areas. However at some sampling sites fibre counts exceeded the urban ambient air standard 0.0001 f/cc according to Holland and Smith (1997). The Occupational Safety and Health Administration and American Conference of Governmental Industrial Hygienists require that workers are not to be exposed to more than 0.1 f/cc (OSHA, 1998; ACGIH, 1998). In 1983, the EPA made the proactive statement that "exposure to airborne asbestos regardless of the level involves some health risk" (EPA, 1983).

A threshold of effect has never been found for asbestos. However, several lines of argument also suggest that any threshold for mesothelioma is at a very low level. Some cohorts (Rossiter and Coles, 1980; Thomas et al., 1982; Neuberger and Kundi, 1990) have shown mesotheliomas where no excess lung cancer was seen, and the proportion of mesothelioma cases was high in populations where no source of asbestos exposure can be identified. Hodgson and Darnton (2000) suggested that relatively brief asbestos exposures may carry a low, but non–zero, risk of causing mesothelioma. Ilgren and Browne (1991) argued against dose response mesothelioma threshold and they concluded that the existence of zero cases in a dose category (human or animal) should not be interpreted as a zero risk.

Although, asbestos is banned in Egypt, it is still being imported for manufacturing purposes. Allen (2006) reported that asbestos is still being used in Egypt in the production of insulation boards, asbestos–cement water pipes and fire resistant clothing. Abdul Salam (2006) described the current situation regarding asbestos use in Egypt as "anarchy" with people still using asbestos despite the fact that it can no longer be used.

5. Conclusion

This review reinforces that geographical areas and occupational locations associated with exposure to asbestos fibre counts continue to drive mesothelioma. Populations living in the vicinity to asbestos sources have proved to be exposed to higher environmental asbestos counts. Pleural mesothelioma is related to asbestos fibres regardless of their counts. Mesothelioma mortality rate was relatively high among female subjects and chrysotile is the main cause for mesothelioma in Egypt. The improper and careless disposal of wastes is the main reason for releasing fibres in high counts. There is a clear need for stronger legislative measures to eliminate asbestos entirely, relocate factories outside the residential areas and improve industrial hygiene measures.

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